On Aiding Supervision of Groups in the Mobile Context

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ABSTRACT

In this work we introduce and examine the possibility of aiding in the oversight of mobile groups by assisting the supervisor in his or her awareness of the physical presence of members. The subject matter of this paper is to find out whether or not that is viable, and why. Our approach is thus: we have lead interviews with users representative of the target audience in order to gather information on group supervision and define requirements. Secondly we have assessed five wireless technologies for use in an actual implementation. As a third step we have engineered an actual prototype based on the information gathered thus far. Lastly, this device was evaluated both under laboratory conditions and in the field. We find high acceptance and demand among prospect users and conclude from evaluation that there are strong indications to the viability of reducing the workload of supervising mobile groups by assisting the person in charge with awareness of physical presence of members.

Author Keywords

Assistance; group; supervision; mobile; presence awareness; assisted supervision

ACM Classification Keywords

H.5.2 user interfaces: user-centered design

General Terms

Experimentation; human factors; verification

INTRODUCTION

It is easily observable that managing a group of people is difficult, especially in the mobile context. The person in charge has to ensure that all members transfer safely to the destination, without anyone getting lost or being hurt. Instantiations of this scenario are, for example, a school class on a field trip or a tourist group on its way through a foreign city. The supervisor of such a group usually has to do some heavy multitasking to assure that all of his or her charges stay out of harms way while navigating, e.g., an urban area. That being established, the idea is that we may aid a group supervisor by providing electronic assistance to the task of checking for absentees, thus reducing the number of things he or she has to keep in mind simultaneously. We seek to investigate this possibility of improving both working conditions and safety. The challenges, as far as human-computer-interaction is concerned, of providing such electronic assistance are to design a mobile device that provides an interface that is usable even in highly stressful situations. It also provides exactly the information needed to assist with group supervision. The high cognitive load and fragmented nature of the user's attention span in such demanding environments is discussed in e.g. [8]. In order to evaluate the prospect of assisted group supervision, we work together with a group of people deemed representative of the target audience: primary school teachers. They provide know-how on best-practices as well as known problems and serve as test users for the prototype's evaluation.

The goal of this paper is to investigate the viability of assisting group supervisors by aiding their awareness of physical presence. "Viability" in this context refers to both technological feasibility (meaning whether it is possible to implement at all) as well as usefulness in the intended setting (meaning whether it indeed has potential to support the user). Herein, we provide some primary research on this. To the best of our knowledge, we are first to explore this avenue of assisting group supervisors; at this point we know of no prior publications in academia on that topic.

Our approach to examining the subject matter involved four steps: Leading interviews with users experienced in supervising groups, doing an assessment of available wireless technologies, implementing a prototype, and finally the evaluation thereof. Each of these steps and its results will be described in turn before we discuss the conclusions drawn from the collected data at the end of this paper. In the conclusion, we will focus on drawing up design guidelines for systems such as the one proposed in this article.

PRELIMINARY INTERVIEWS

"The first step in the usability process is to study the intended users and use of the product" [7, p. 73]. Therefore, prior to designing and implementing a prototype, we went out and talked to users who have previous experience with supervising groups of people on the move: primary school teachers. As wresting control over large groups of sometimes unruly individuals is their source of daily income we expected them to provide valuable feedback based on experience. There were several goals to these interviews: firstly we wanted to gauge reactions to the idea of electronic assistance to group supervision; we considered outright rejection to be possible and wanted to know the reasons why, if this was indeed the case. Secondly, we wanted to learn about typical problems encoun-

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tered when supervising groups, which situations aggravate those and what best practices currently are employed to mitigate this. Thirdly, we tried to find out which features our electronic assistance would have to provide to make it useful. In total there were six participants ranging in age from their early twenties to fifties, the average being in the mid-thirties. The interviews were done at the participants' work spaces, i.e., the rooms of their respective classes, to provide a familiar setting and relaxed atmosphere. The talks were held in a semi-structured manner: a small number of key points with relation to the topics mentioned above was always addressed, but free talking was encouraged at all times.

Initial reception of the idea was very favourable with remarkably little reservation against an "intrusion" by electronic assistance. We identified a core set of requirements, which were mentioned by all participants. These are rather basic and consist of: detecting complete absence of any group member, displaying names of absentees and providing an easily recognisable, auditive alarm signal. Desired features mentioned by at least three of the participants were: setting up and managing a list of members currently with the group prior to venturing out, being able to chose the maximum distance, which the group member are allowed to venture from their supervisor, and sounding an alarm not only if a group member is completely separated from the group but also if they leave a certain "safe zone" (meaning, effectively, an early warning system). Furthermore, exact positioning of all group members was called for, put not considered vital.

We were able to classify three different types of situations during which group supervision is difficult, with an example of each of these being mentioned by at least three of the participants. Firstly, there are such scenarios as require moving past a certain point under time constraints; named examples include boarding or exiting a public transport vehicle or crossing a street. Secondly, there are situations where the group remains in an area with wide boundaries for a prolonged period, such that the supervisor may lose visual contact with members; an example for this is staying on a playground. Lastly, there was mention of crossing highly frequented areas, where the flow of people may disrupt the group's structure; think of, e.g., moving through a subway station.

ASSESSMENT OF TECHNOLOGIES

To find a wireless technology that fits the needs of a prototype system we have compared five wireless technologies currently available: Wi-Fi, Bluetooth, GPS, ZigBee, and Ultra-Wideband. The criteria for this assessment were maximum range of communication, reliability (resilience to interference), energy consumption as well as availability (accessibility on the consumer market). With these in mind, *ZigBee* was chosen for use in the prototype. It is a standard that builds additional layers on top of the IEEE 802.15.4 specifications and is concerned with the setup and routing of multi-hop networks [2]. ZigBee defines three different device types, which enable the formation of various topologies; most importantly and relevant for this work it is able to form mesh networks. Put simply, every node of a certain type is in theory able to expand the network. As an in-depth description of ZigBee is

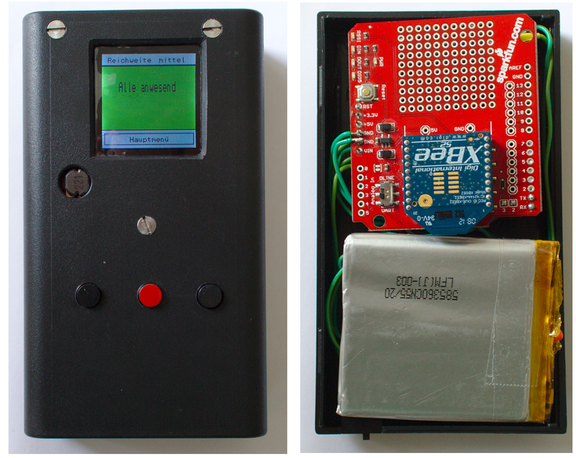

Figure 1. Supervisor's prototype (top-down view).

beyond this paper, please refer to other literature like e.g. [2, 3]. Mesh networking is one of the reasons why we chose to use ZigBee. It allows to mitigate range restrictions imposed by a star topology and provides robustness due to multiple available paths [1, 4]. Also working in favor of this technology is its low energy consumption as compared to other wireless technologies [5, 6].

It should be noted that Ultra-Wideband does, on paper at least, provide better transmission characteristics than ZigBee for our purposes, featuring good range and robustness paired with low energy consumption. Our reason for not using it was the lack of availability in prototyping platforms or other commercial products rather than any obvious technological shortcomings. Bluetooth and Wi-Fi on the other hand differ too much in their intended application profile (high data throughput vs. energy consumption and mobility) to recommend themselves for this use case. GPS was discarded due to its also high energy consumption in combination with outages when indoors or even in urban canyons [9].

PROTOTYPE

To evaluate the prospect of assisting with group supervision we have constructed a prototype based on the information gathered during the preliminary interviews. It consists of one main device intended for the group supervisor (Figure 1) as well as five different wearable devices for group members. The latter include high visibility vests, a pendant, and two kinds of headwear. The more successful designs (refer to next Section) may be seen in Figures 2 and 3.

Figure 2. Pendant item for group members.

Figure 3. High visibility vest for group members.

The prototype is based on the Arduino platform, with its LilyPad variant being used for the wearable group member devices. They communicate with each other using Arduino's XBee wireless modules, which provide an implementation of the ZigBee standard, including mesh networking capabilities. The way it works is that the main device does periodic checks on the difference between the current time and the last time a device has reported in. If this delta crosses a certain threshold the supervisor is alarmed of that specific group member being missing. This is enough to implement the core functionality as identified during the preliminary interviews. Further discussion of the exact workings and configuration of the prototype are beyond this paper.

The prototype's interface is kept rather simple on purpose. The main screen is visible in Figure 1. It shows a green background and a text saying that everyone is present (if this is indeed the case). Should contact be lost with one of the other devices, the screen turns red and displays the name of the person in question. In addition, an audible alarm is sounded which may be silenced by the press of a button. No other interaction is required during regular operations. There is a menu structure, accessible from the main screen, which allows adding and removing of group members and provides a few settings (e.g., for switching off sound); this menu structure does not necessarily have to be accessed while the group is moving. Care has been taken to always display important information on the main screen, where it is quickly accessible. All interactions are carried out via three hardware buttons located under the display. The left and right button are used when navigating menus to move the current selection up and down, respectively. The center button (red) is used for confirmations such as acknowledging an alarm or entering a menu.

Due to the highly stressful environment that the user will be operating in frequently, we recommend to keep a focus on prominently and concisely displaying important information where the user may access it easily; assume that he or she will not have more than a few moments time to interact with the device. We have deliberately decided to forgo the use of touch-based input in favor of hardware buttons. The decision was in part due to remarks from participants during the preliminary interviews, where they stated to prefer hardware button for their robustness and resilience to dirt and water; this is a view that we agree with. Independently of these opinions we have preferred hardware buttons because they provide tactile feedback and do not require visual contact to be maintained with the screen during interaction, both of which are desirable characteristics for situations with many distractions. Ultimately, omitting touch-based input has served us well in this specific use case and was received positively.

EVALUATION

During the last phase of our work, the prototype was evaluated both under laboratory conditions and in the field. For test users we remained with the primary school teachers that we had already talked to during the preliminary interviews. We hoped that the users being familiar with our work would make them feel more tied into the endeavor and thus improve the quality of feedback.

Before venturing out into the field, the prototype carried by the group supervisor was first evaluated in a controlled environment. The "controlled environment" in this case was again the class rooms of the participating teachers, same as during the preliminary interviews. Four of the six teachers already involved through the earlier interviews were chosen as test users. Their age was deliberately kept diverse with the youngest participant being in her early twenties and the oldest just turning fifty. These tests revealed only minor flaws in the structure of the device's menus, but indicated its readiness for field testing otherwise. We would like to concentrate on the latter in this paper, as it is more relevant to answering the question of viability for practical use.

Field Testing

Having assured that the device intended for the supervisor is ready for field testing as far as functionality and usability are concerned, we conducted evaluation in a realistic environment. To this end we have accompanied a teacher and her class during field trips on two occasions. They would use the public transport system to get to a nearby park and playground for a stay of two to three hours before returning to school. We considered this a good context for evaluation, as it would include all three of the problematic situations we identified earlier (see section "Preliminary Interviews"). The whole class consisted of 25 children, five of which had equipped wearable prototypes during the trip; you can see them being worn on Figure 4. Having only five items available, we were not able outfit all of the class with prototypes (refer to "Caveat" at the end of this article); instead they were rotated between different pupils on a regular basis so we could observe a good number of wearers. The teacher served as test user for the main device; she was the oldest person of the demographic participating in evaluation (being 51 years of age) and already familiar with the project, having taken part in the earlier interviews and usability tests.

The field tests have provided additional insights into the challenges of supervising groups in the mobile context as well as useful observations regarding the prototype and its usage. Specific to the use case of school classes (or groups of children in general) is the insight that there was a remarkably high acceptance among them as far as the prototypes were concerned. Even after the novelty factor had worn off, the behavior of the children wearing one of the items ranged from unconcerned to being proud of their adornments. Their usual behavior on the playgrounds and in transit did not seem to be affected at all, an observation that was confirmed by the teachers; we consider the minimal impact of our devices to be a positive characteristic. Also mostly (yet not exclusively) applicable to the context of younger target audiences is the finding that of the different types of items being tested, the high visibility vests proved to be the most practical. They were preferred by the majority of children and also liked by the teachers due to their high visibility. They may also be worn as the top layer of clothing independent of other garments and outside temperatures, which makes them the most versatile.

Observing the teacher using the prototype showed how important the use of concise presentation of information is. Between being riddled with questions by some of the children, keeping an eye on the others and making sure the group catches the next bus or train, she barely had time to glance at the display once an alarm went off before having her attention drawn elsewhere again; this short attention span is in accordance with the findings of [8]. For this reason, our prototype displays the current group status prominently and easily accessible on the starting screen. In the concluding talks the teacher stated using the device did not encumber her in the usual routines and activities related to group supervision. This is as much a positive indication for the device's usability as we can hope for with regards to the current state of the prototype – please refer to section "Caveat" for further remarks on this.

As for the technological aspects of the prototype, the performance of Arduino's own implementation of ZigBee was acceptable. Due to the rather low-power transmissions usually employed by ZigBee radios, some false alarms were triggered in environments that were rich with interferences, such as crowded trains and buses. Such problems were encountered in three out of four rides with public transports. These issues were not encountered in outside areas; the system worked reliable both while the group was mobile or staying within a designated area (e.g. a playground). However, false alarms are a serious problem as they undermine the user's trust in the system and lead to unnecessary commotion within the group as the teacher tries to determine where the "lost" members are. We suspect the number of devices may have been too low or the routing too inflexible to achieve positive effects from mesh networking in such environments and with regards to a rapidly shifting network topology. An implementation on a larger scale with more devices should be able to handle such situations better through the availability of additional routes to the main device. Further investigation on this topic is required to draw significant conclusions.

Figure 4. Children wearing the prototypes: cap, high visibility vest (twice), cap, and pendant, left to right.

CONCLUSIONS

In this paper we have presented our approach to assisted group management in the mobile context by aiding the supervisor in his or her awareness of absentees. We attempted this by providing a prototype that informs of the absence of group members. Acceptance among users representative of the target audience (teachers) was high and the idea was received favorably by all participants. Evaluation of a prototype has provided us with strong indications of the viability of this approach. Technologically the device has held up to expectations under most circumstances, providing a stable network where interferences are not too prominent; it is our opinion that a more stable performance can be achieved in the future. As far as the usefulness of the device is concerned, we have received positive feedback from our target audience after evaluation. We feel, thus, that strong indications are given for the viability of the avenue presented in this paper.

We have found the following guidelines to designing a mobile assistance system for assisting in group management: first and foremost, the system should be kept simple both in its user interface and functionality. In case of the interface, simplicity is necessitated by the environment the user operates in. People in charge of mobile groups are bound to be under stress and accordingly will have little time to spare for interactions. It is therefore important to always display relevant information prominently, concisely and easily accessible on the screen; furthermore interactions should be kept to a minimum and, if unavoidable, short in duration while the group is mobile. For these reasons, the prototype always displays the group status on the home screen and demands only a single interaction after setup (which is acknowledging an alarm by pressing any button). As was mentioned earlier, hardware buttons should be preferred for user input as they provide tactile cues and do not require visual contact to be maintained with the screen, as do touch-based input variants. Apart from the user interface, functionality should also be kept to a manageable extent in order for an assistance system to remain useful. The following functionality, provided by the prototype, was shown to be sufficient: group setup (i.e. declaring who is in the group) prior to moving out, sounding an alarm in case of missing group members and displaying their names. We urge to weigh the addition of more functionality against the risk of unnecessarily bloating the system, thereby making it more cumbersome to use.

Lastly we would like to point out the importance of keeping the presence awareness aid local. What we mean by that is to not utilize technologies which facilitate positioning of individual group members on a global scale, such as geolocation through GPS or GSM cells. Apart from the technological shortcoming of not being able to operate without certain infrastructure being present, these technologies are also likely to diminish acceptance of the system. Our society currently experiences a sensitization towards the issues of surveillance and tracking. The children themselves did not seem to mind the prospect, but their parents are likely to [10]. Likewise, we suspect skepticism towards these technologies from adult group members in other use cases. Indeed, multiple participants have also issued concerns on this topic during preliminary interviews and evaluation. Their fears were alleviated once we assured them that the prototype only tracks within a certain range around the supervisor, not globally. We are well aware of the added possibility that the usage of, e.g., GPS would bring, yet we urge to refrain from global tracking for the sake of acceptance among the prototype's target audience.

Caveat

There is currently no full-scale implementation of the prototype – meaning that there are only five child devices and one for the supervisor. Consequentially, evaluation in the field could not be done to an optimal extent. The test user did not have the option to rely on it as they were intended to with a more complete system. A complete system would feature at least thirty devices to be of use in the context of school outings. But with only a subset of pupils under assisted supervision, the teachers had to do their regular routines of counting heads and checking for absentees in addition to operating the prototype. It was thus hardly feasible to conduct measurements of cognitive load and stress or the reduction thereof. Ultimately this means that, while we feel strong indications are given for the usefulness of the prototype by the favorable responses of our test users, we cannot prove it with further data points yet.

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